Global Decoupling On Ramp

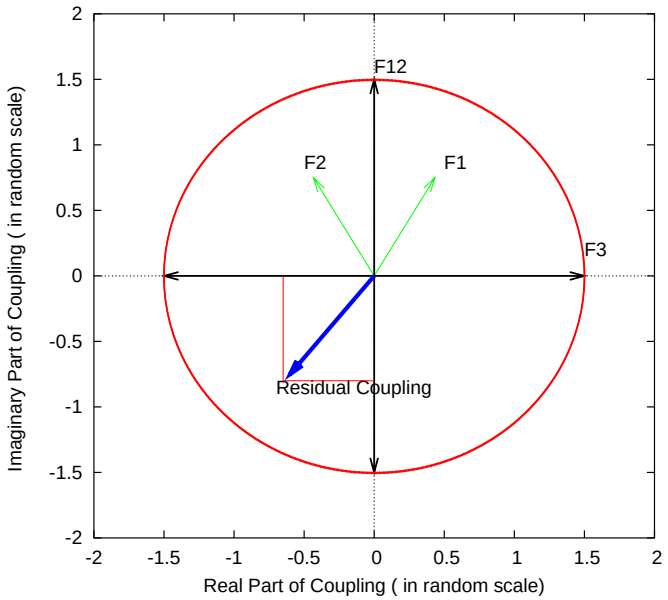
Y. Luo for SkewQ Modulation Team

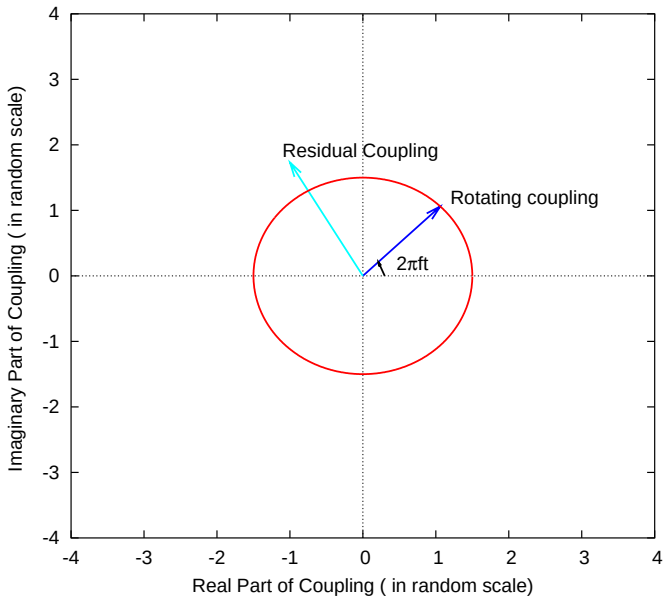
- Review of off-line stuy of skew quadrupole modulation
- Review of the beam experiments in last run
- Status of on-line application program
- Strategy for the coming Run
- Possible challenges we may face
- Time support is needed

Skew Quadrupole Modulation Technique

- Skew quadrupole modulation is a fancy technique to detect the residual global coupling through the skew quadrupole strength modulations.
- It is fast. Every modulation time can be reduced to several seconds. At most two modulations are needed.
- It is safe. The modulation strength is small. It never killed a beam in the beam experiments in last run.
- good resolution. With the high resolution PLL system, the tune modulations are precisely measured.
- It is robust. More or less connected to lattice and the detailed PLL data.
- Direct applying to coupling correction. From the modulation tune response, the corrections can be applied.

Two Skew Quadrupole Modulations





Coupling amplitude modulation

Coupling phase modulation

Coupling Amplitude Modulation

- Tune split

$$\begin{aligned}(Q_1 - Q_2)^2 &= \Delta^2 + |C^2_{res}|^2 + \frac{1}{2}|C^2_{mod,amp}|^2 \\ &\quad +2|C^-_{res}||C^-_{mod,amp}|\cos(\varphi)\sin(2\pi f t) \\ &\quad -\frac{1}{2}|C^-_{mod,amp}|^2\cos(4\pi f t) \end{aligned} \tag{1}$$

- Projection ratio

$$\kappa = \frac{|C^-_{res}|\cos(\varphi)}{|C^-_{mod,amp}|}. \tag{2}$$

- Data processing methods: FFT and Linear Regression

From the projection ratios to get residual coupling, then correction follows. If orthognal modulations,

$$\begin{cases} (k_s dl)_{corr_1} &= -\kappa_1 \times (k_s dl)_{amp,modu_1} \\ (k_s dl)_{corr_2} &= -\kappa_2 \times (k_s dl)_{amp,modu_2} \end{cases} \tag{3}$$

Coupling Phase Modulation

- Tune split

$$\begin{aligned}(Q_1 - Q_2 - p)^2 &= \Delta^2 + |C^-_{res} + C^-_{mod}|^2 \\ &= \Delta^2 + |C^-_{res,amp} \cdot e^{i\phi_{res}} + C^-_{mod,amp} \cdot e^{i2\pi ft}|^2 \\ &= \Delta^2 + |C^-_{res}|^2 + |C^-_{mod}|^2 + 2|C^-_{res}||C^-_{mod}| \cos(2\pi ft - \phi_{res}).\end{aligned} \tag{4}$$

- Scaling factor

$$k = \left(\frac{\Delta Q^2_{max} - \Delta Q^2_0}{\Delta Q^2_{max} - \Delta Q^2_{min}} - \frac{1}{2}\right)^{-1}. \tag{5}$$

- Data processing methods: DIVISION

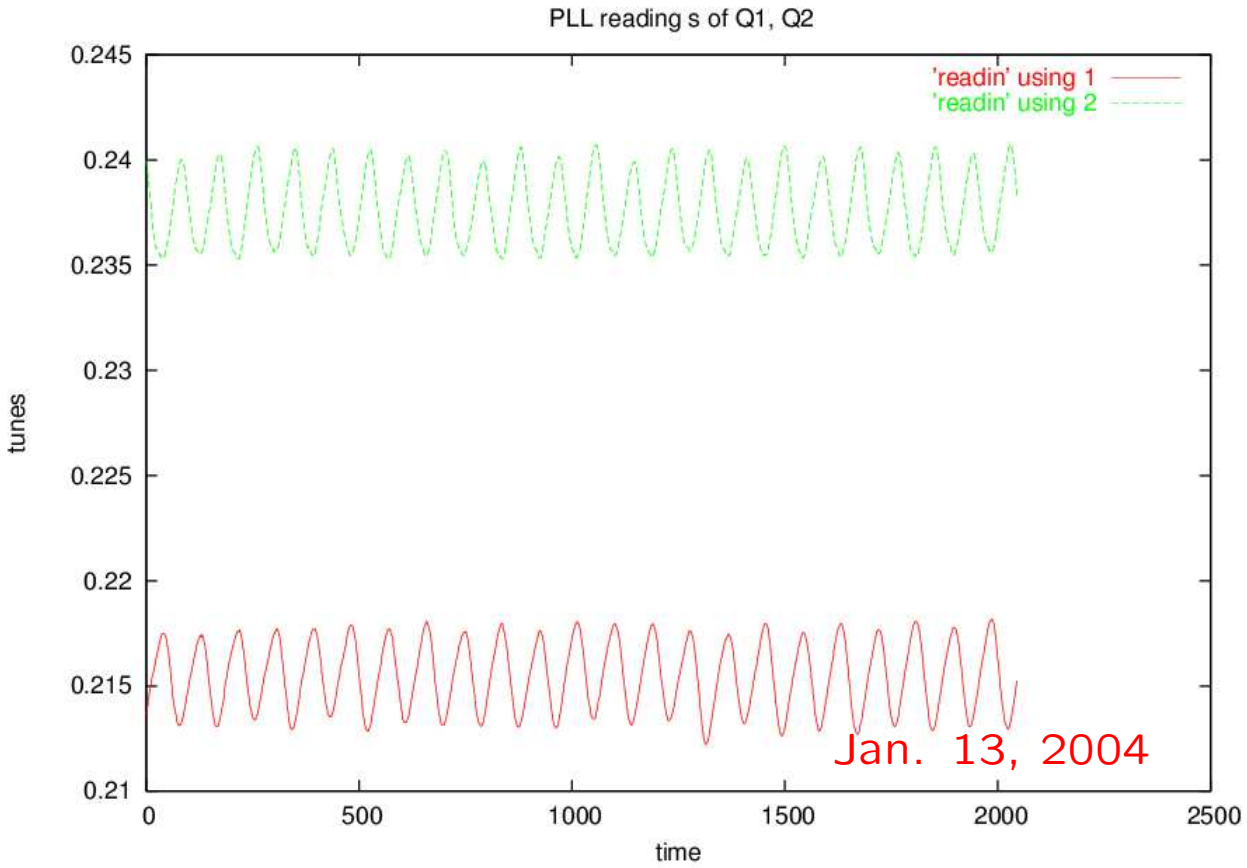
multiply k to the skew quadrupole modulation strengths at the minimum tune split to obtain the correction strengths

Beam Experiments in Run'04

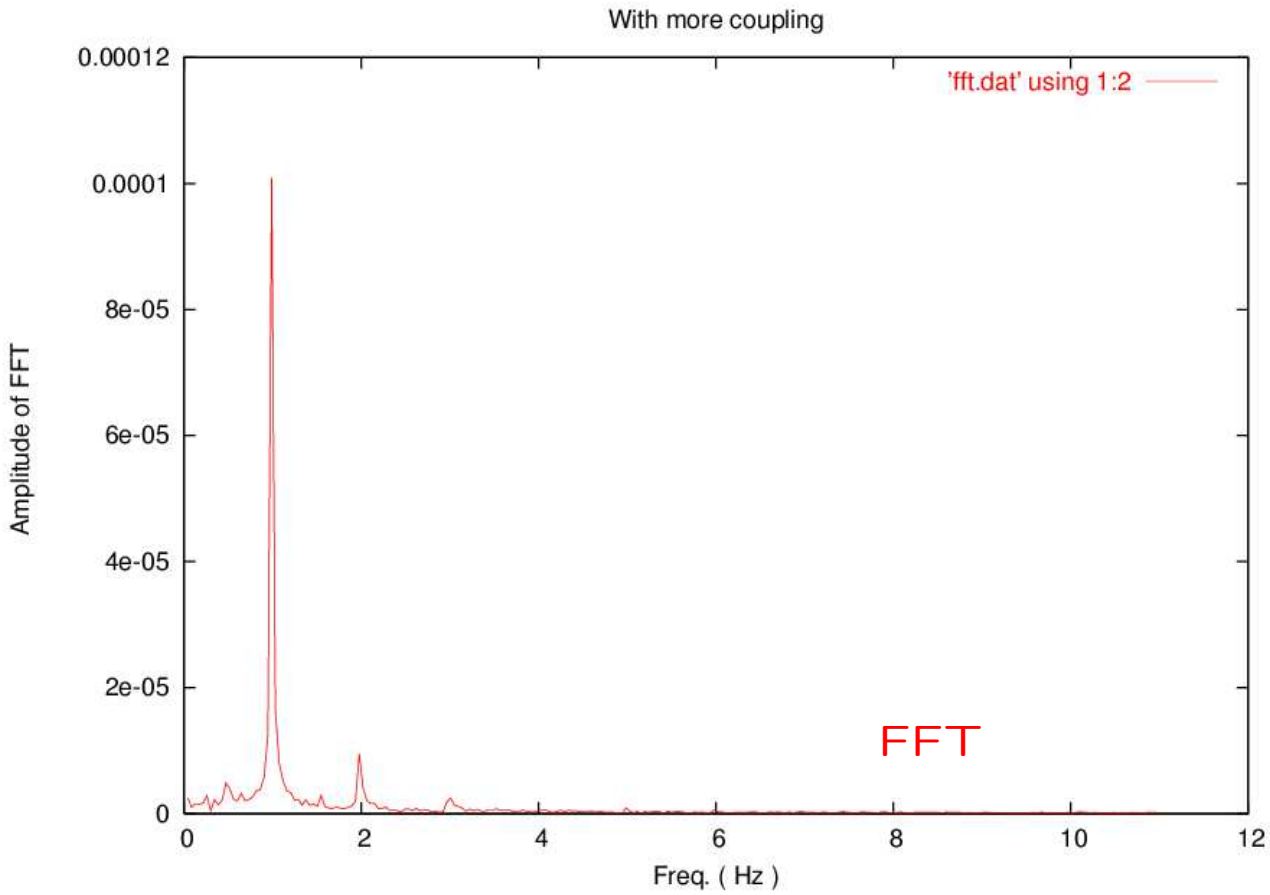
Beam Experiments

Session	Goal	Scheduled time (hrs.)	Observation
2004_Jan_6	injection	2.0	Two peaks seen
2004_Jan_13	injection	2.0	Measurement at injection
2004_Jan_27	ramp	2.0	PLL only one tune modulated Some data take at injection
2004_Feb_03	ramp	2.0	PLL lose locking data taken on ramp/ at store
2004_Feb_11	ramp	1.5	part data useful
2004_Feb_25	ramp	2.0	part data useful
2004_Mar_11	correction	0.5	test scheme at injection
2004_Mar_27	injection	1.5	test R. Lee's on-line program
2004_May_14	correction	0.5	test scheme at store

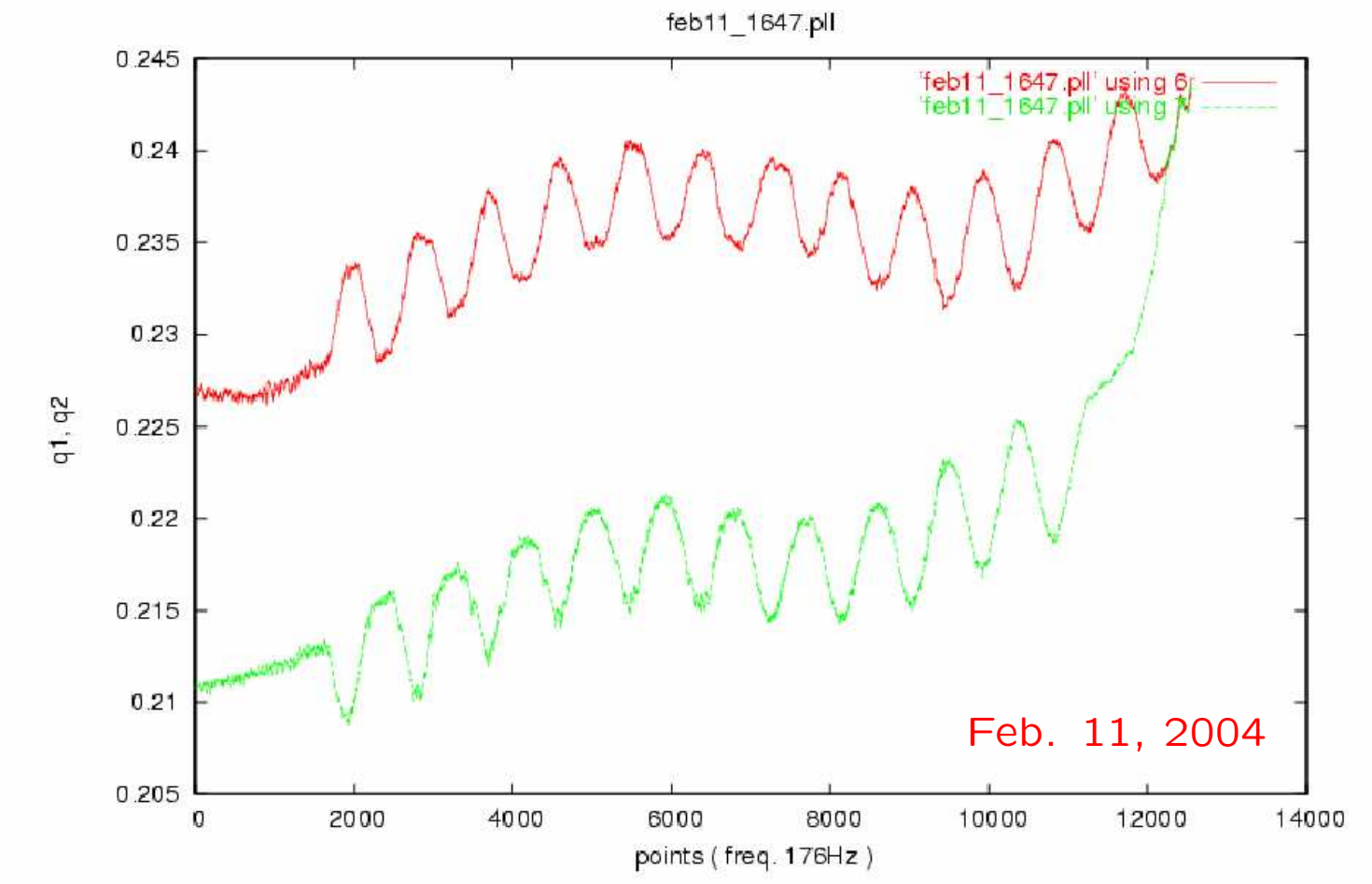
Example at Injection



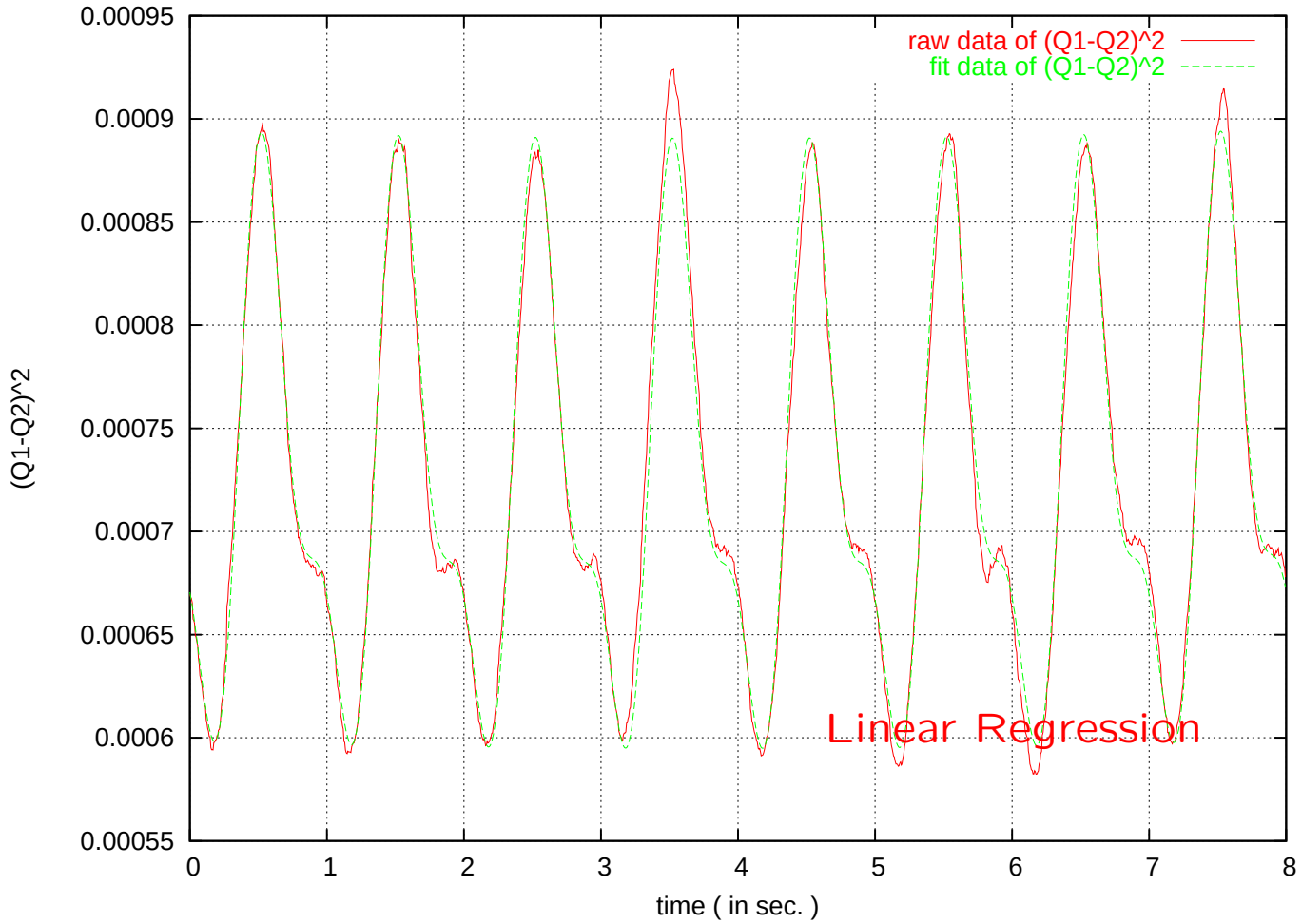
Example at Injection



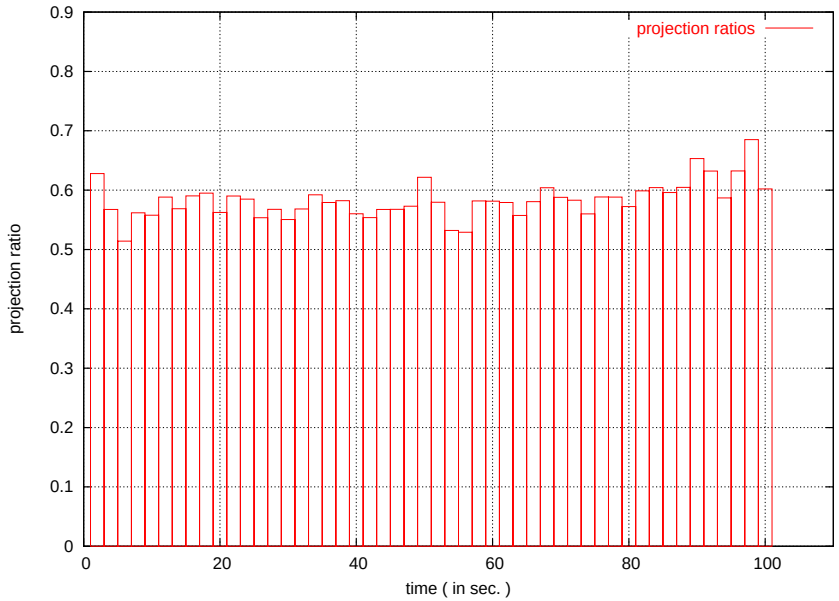
Example on the Ramp



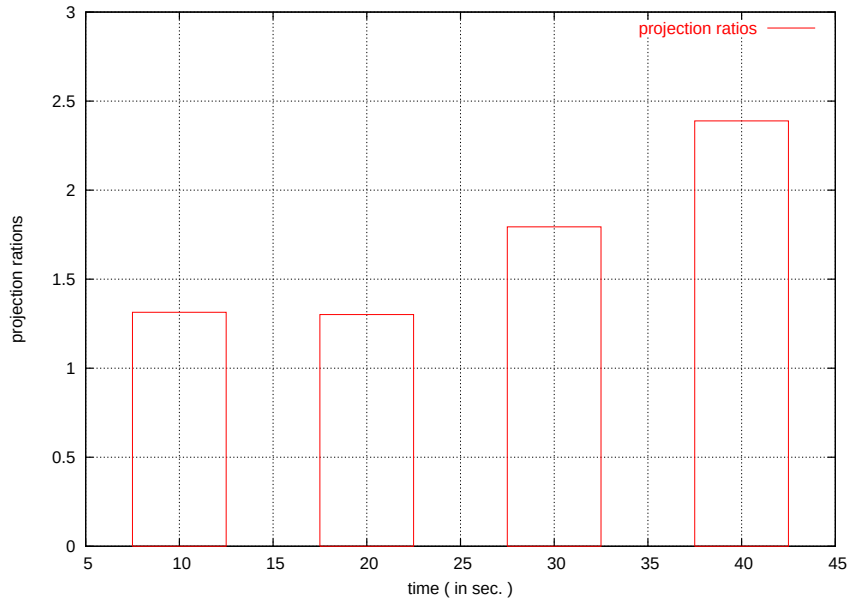
Fast Data Processing



Projection Ratio from Linear Regression



at injection



on the ramp

Check the Theory

Residual coupling

first measurement

condition	Amplitude(A)	Angle (deg.)
(F1, F2)	1.596	107.49
(F2,F3)	1.367	101.41
(F1,F3)	1.629	97.79
(F2, F1F3)	1.417	102.95

Average: 1.2 / 99.8

Second measurement

condition	Projection ratio	Angle(deg.)
(F1,F2)	1.609	64
(F2,F3)	2.31	100
(F1,F3)	1.18	123
(F1F3,F3)	1.647	109
(F1F3,F2)	2.06	93.8
(F1F3,F1)	1.434	146.8

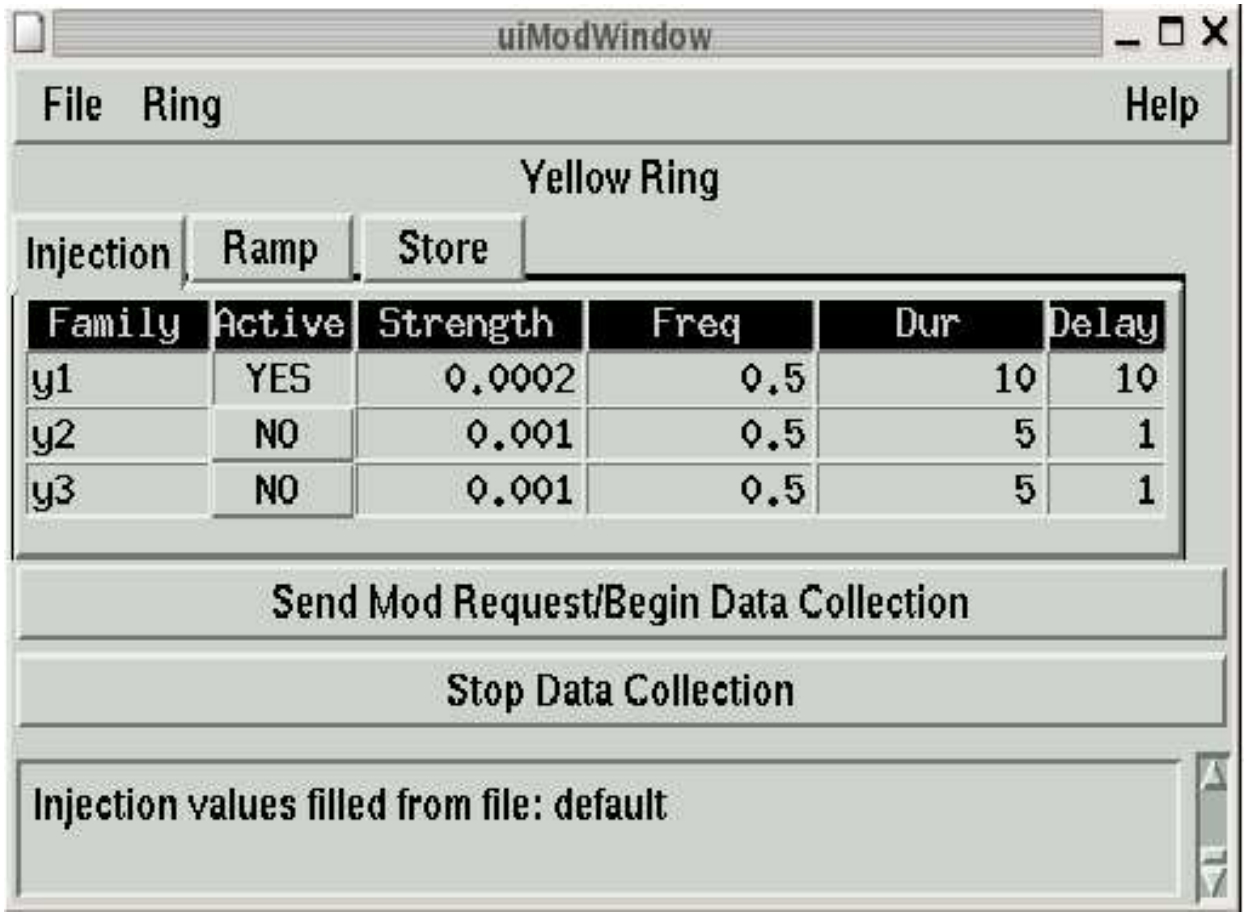
Average: 1.793 / 106.45

For coupling correction: I gave residual coupling 1.5A/ 100

Lessons from last run

- Low Efficiency All data are off-line processed, which took a lot of time and gave very slow responses.
- Emphsizing Ramp more than 2/3 beam experiments went to ramp coupling measurement. However, ramp measurement had no breakthrough for a long time due to PLL losing locking. In fact injection and store are the best testbeds. We should first succeed there.
- Emphsizing measuremnt No real correction done. ONly onece to compare the measurement result to the setting.
- Limited by amplitude modulation scheme shortcomings of amplitude modulations. The phase modulation will help ?

Status of on-line application program



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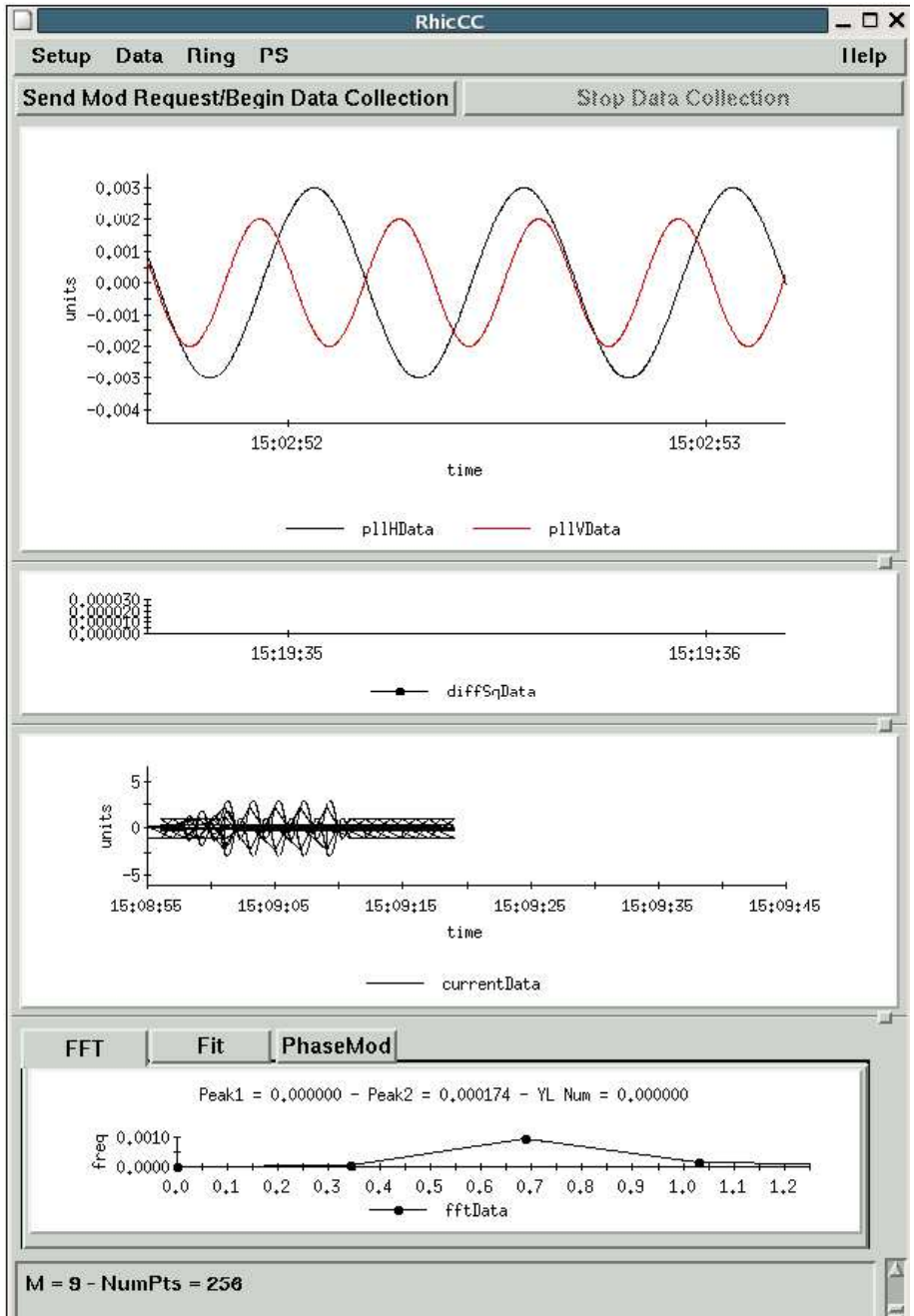

Results from First Dry Run

The first Dry Run:

- Jon's Program tested.
- Al's script tested.
- Sending modulation request –passed.
- PLL and current readback –passed.
- Modulation time order –passed
- Modulation amplitude –passed
- Modulation frequency –passed

Existing and Unfinished problem list

- WFG manager needs upgrading.
- Al's Perl script needs further check.
- SkewQ strength replacing power supply current.
- Linear Regression programming hasn't be checked.
- Phase modulation data processing hasn't be checked.

Strategy For The Coming Run

- One goal: quick applying the skew quadrupole modulation technique to RHIC
- Time schedule: make use of the startup of RHIC to test the subsystems, the programs, to fully expose problems and to fix them.
- Emphsis: focus on coupling phase modulation, other methods as backup in emergency.
- Support from you: every measurement takes less than one minute, your support is indispensable.
- Limited dedicated beam experiments : to systmatically do some specific researches.

Possible challenges we may face

- PLL losing lock:

reduce modulation periods,
use smaller modulation frequecy,
and smaller modulation strengths,
artifically make the tune split larger,
appropriate locking window width .

- Program Problems:

not a big deal,
they can be easily fixed.

- Power supplies:

need pay attention to,
all current data will be logged.